CLAIMS

What is claimed is:

1. A tool for determining the amount of a carbon isotope in a fluid, comprising:

a laser source emitting at least one laser beam;

a first volume of the fluid positioned so that at least a first portion of a laser beam passes through the fluid;

a first downstream optical detector positioned to detect said first beam portion after said first beam portion passes through said first volume, said first optical detector emitting a first downstream signal corresponding to the strength of said first beam portion after passing through the first volume;

a reference cell containing a concentration of the isotope and positioned so that at least a second portion of a laser beam passes through said concentration;

a second downstream optical detector positioned to detect said second beam portion after said second beam portion passes through said reference cell, said second optical detector emitting a second downstream signal corresponding to the strength of said second beam portion after passing through said reference cell; and

a microprocessor receiving said first and second downstream signals and calculating therefrom a parameter indicative of the presence of the isotope in the fluid, wherein the parameter comprises enrichment or depletion of the isotope.

2. The tool according to claim 1 wherein said first and second beam portions comprise a single beam.

3. The tool according to claim 1 wherein said first and second beam portions comprise separate beams.

4. The tool according to claim 1 wherein said first fluid volume is contained in a cell.

5. The tool according to claim 1 wherein said first fluid volume is contained in a conduit.

6. The tool according to claim 5 wherein the conduit contains flowing fluid.

7. The tool according to claim 1 wherein said microprocessor calculates a concentration of the isotope in the fluid relative to the concentration of the isotope in the reference cell.

8. The tool according to claim 1 wherein said microprocessor calculates a quantitative concentration of the isotope in the fluid.

9. The tool according to claim 1 wherein said laser source is a tunable laser source.

10. The tool according to claim 1 wherein the carbon isotope is part of a hydrocarbon.

11. The tool according to claim 1 wherein said first volume and said reference cell are at substantially the same temperature.

12. The tool according to claim 1 wherein said first volume and said reference cell are in a wellbore when said first and second beam portions pass through said first volume and said reference cell.

13. The tool according to claim 1 wherein said first volume and said reference cell are not in a wellbore when said beam portions pass through said first volume and said reference cell.

14. The tool according to claim 1, further including a first upstream detector detecting said first beam portion before said first beam portion passes through said first volume and emitting a corresponding first upstream signal; and a second upstream optical detector detecting said second beam portion before said second beam portion passes through said reference cell and emitting a corresponding second upstream signal.

15. The tool according to claim 14 wherein said microprocessor receives said first and second upstream signals and uses said first and second upstream signals in calculating said parameter indicative of the presence of the isotope in the fluid.

16. The tool according to claim 1 wherein said first and second downstream signals are indicative of the transmittance of said first and second beam portions through said sample and reference cells, respectively.

17. A method for providing data indicative of the isotopic composition of a hydrocarbon fluid, comprising:

(a) providing a reference fluid having an isotopic composition in a reference cell;

(b) defining a sample of the hydrocarbon fluid;

(c) providing at least one laser beam;

(d) normalizing at least one parameter of the reference cell;

(e) passing at least a portion of a laser beam through the reference fluid as a reference-measurement beam and measuring said reference-measurement beam after it passes through said reference fluid;

(f) passing at least a portion of a laser beam through the sample as a sample-measurement beam and measuring the sample-measurement beam after it passes through the sample; and

(g) calculating a parameter indicative of the presence of the isotope in the fluid using measurements made in steps (e) and (f), wherein the parameter comprises enrichment or depletion of the isotope.

18. The method according to claim 17 wherein the reference-measurement beam and the sample-measurement beam comprise a single beam.

19. The method according to claim 17, further including the step of splitting a laser beam to form a reference-measurement beam and a sample-measurement beam, such that the reference-measurement beam and the sample-measurement beam comprise separate beams.

20. The method according to claim 17 wherein step (b) comprises placing the sample of the hydrocarbon fluid in a sample cell.

21. The method according to claim 17 wherein step (b) comprises providing a conduit through which the hydrocarbon fluid flows.

22. The method according to claim 17 wherein step (f) is carried out while the hydrocarbon fluid is flowing through the conduit.

23. The method according to claim 17 wherein in step (g) a microprocessor calculates a concentration of the isotope in the fluid relative to the concentration of the isotope in the reference cell.

24. The method according to claim 17 wherein in step (g) a microprocessor calculates a quantitative concentration of the isotope in the fluid.

25. The method according to claim 17 wherein said measurements provide information relating to the carbon isotopic composition of individual compounds in a hydrocarbon gas mixture.

26. The method according to claim 25 wherein the individual compounds are selected from the group consisting of: methane, ethane, propane, iso- and normal butane, and iso- and normal pentane.

27. The method according to claim 17 wherein the laser beam is provided by a tunable laser source.

28. The method according to claim 17 wherein steps (e) and (f) are carried out at substantially the same temperature.

29. The method according to claim 17 wherein steps (e) and (f) are carried out in a wellbore.

30. The method according to claim 17 wherein step (b) is carried out in a wellbore and steps (e) and (f) are not carried out in a wellbore.

31. The method according to claim 17 wherein at least one of said first and second beams passes through an upstream detector before passing through a cell.

32. The method according to claim 17 wherein step (g) is carried out using the transmittance of said reference- and sample-measurement beams through said reference and sample cells, respectively.

33. The tool according to claim 1 wherein the reference cell contains an unknown concentration of the isotope.

34. The tool according to claim 1 wherein the reference cell contains a known concentration of the isotope.

35. The method according to claim 20 wherein step (b) comprises normalizing the at least one parameter of the reference cell to at least one parameter of the sample cell.

36. A method for providing data indicative of the isotopic composition of a hydrocarbon fluid, comprising:

(a) providing a reference fluid having an isotopic composition in a reference cell;

(b) defining a sample of the hydrocarbon fluid;

(c) providing at least one laser beam;

(d) passing at least a portion of a laser beam through the reference fluid as a reference-measurement beam and measuring said reference-measurement beam after it passes through said reference fluid, wherein the reference-measurement beam is measured by a first upstream optical detector and a first downstream optical detector;

(e) passing at least a portion of a laser beam through the sample as a sample-measurement beam and measuring the sample-measurement beam after it passes through the sample, wherein the sample-measurement beam is measured by a second upstream optical detector and a second downstream optical detector; and

(f) calculating a parameter indicative of the presence of the isotope in the fluid using measurements made in steps (d) and (e).

37. The method according to claim 36 wherein the reference-measurement beam and the sample-measurement beam comprise a single beam.

38. The method according to claim 36 further including the step of splitting a laser beam to form a reference-measurement beam and a sample-measurement beam, such that the reference-measurement beam and the sample-measurement beam comprise separate beams.

39. The method according to claim 36 wherein step (b) comprises placing the sample of the hydrocarbon fluid in a sample cell.

40. The method according to claim 36 wherein in step (f) a microprocessor calculates a concentration of the isotope in the fluid relative to the concentration of the isotope in the reference cell.

41. The method according to claim 36 wherein in step (f) a microprocessor calculates a quantitative concentration of the isotope in the fluid.

42. The method according to claim 36 wherein said measurements provide information relating to the carbon isotopic composition of individual compounds in a hydrocarbon gas mixture.

43. The method according to claim 42 wherein the individual compounds are selected from the group consisting of: methane, ethane, propane, iso- and normal butane, and iso- and normal pentane.

44. The method according to claim 36 wherein the laser beam is provided by a tunable laser source.

45. The method according to claim 36 wherein steps (d) and (e) are carried out at substantially the same temperature.

46. The method according to claim 36 wherein step (f) is carried out using the transmittance of said reference- and sample-measurement beams through said reference and sample cells, respectively.

47. A tool for determining the amount of a carbon isotope in a fluid, comprising:

a laser source emitting at least one laser beam;

a first volume of the fluid positioned so that at least a first portion of a laser beam passes through the fluid;

a first downstream optical detector positioned to detect said first beam portion after said first beam portion passes through said first volume, said first optical detector emitting a first downstream signal corresponding to the strength of said first beam portion after passing through the first volume;

a reference cell containing a concentration of the isotope and positioned so that at least a second portion of a laser beam passes through said concentration;

a second downstream optical detector positioned to detect said second beam portion after said second beam portion passes through said reference cell, said second optical detector emitting a second downstream signal corresponding to the strength of said second beam portion after passing through said reference cell;

a pre-dilution cell containing a portion of the fluid positioned upstream of the first volume; and

a microprocessor receiving said first and second downstream signals and calculating from the first and second downstream signals a parameter indicative of the presence of the isotope in the fluid.

48. The tool according to claim 47 wherein said first and second beam portions comprise a single beam.

49. The tool according to claim 47 wherein said first and second beam portions comprise separate beams.

50. The tool according to claim 47 wherein said first fluid volume is contained in a cell.

51. The tool according to claim 47 wherein said first fluid volume is contained in a conduit.

52. The tool according to claim 47 wherein said microprocessor calculates a concentration of the isotope in the fluid relative to the concentration of the isotope in the reference cell.

53. The tool according to claim 47 wherein said microprocessor calculates a quantitative concentration of the isotope in the fluid.

54. The tool according to claim 47 wherein the reference cell contains an unknown concentration of the isotope.

55. The tool according to claim 47 wherein the reference cell contains a known concentration of the isotope.

56. The tool according to claim 47 wherein a third downstream optical detector is positioned to detect said third beam portion after said third beam portion passes through said pre-dilution cell, said third downstream optical detector emitting a third downstream signal corresponding to the strength of said third beam portion after passing through the pre-dilution cell.

57. The tool according to claim 56 further including a first upstream detector detecting said first beam portion before said first beam portion passes through said first volume and emitting a corresponding first upstream signal; a second upstream optical detector detecting said second beam portion before said second beam portion passes through said reference cell and emitting a corresponding second upstream signal; and a third upstream optical detector detecting said third beam portion before said third beam portion passes through the pre-dilution cell and emitting a corresponding third upstream signal.

58. The tool according to claim 57 wherein said microprocessor receives said first, second, and third upstream signals and uses said first and second upstream signals in calculating said parameter indicative of the presence of the isotope in the fluid, and wherein said microprocessor uses said third upstream signal in determining whether and to what degree to dilute the fluid with the diluent.

59. The tool according to claim 47 wherein the diluent comprises nitrogen.

60. The tool according to claim 47 wherein the diluent comprises at least one of nitrogen and at least one noble gas.